Preface

Radiomics is a novel image diagnosis method, that provides valuable diagnostic or predictive information of a patient not only using his/her medical images but also utilizing quantitative image markers extracted from big medical image data of a large number of subjects. In particular, predictive models with high accuracy, reliability, and efficiency are vital factors driving the success of radiomics. Machine-learning based method is capable of “learning” from data and hence can automate and improve the prediction process. Feature extraction is a preprocess of machine learning, which strongly affects prediction performance. Wavelet analysis is one of effective feature extraction methods, and can extract texture information and/or recognize structure from multi-dimensional data such as images, waves, etc.

Based on this background, this thesis describes medical image understanding studies focused on machine learning and wavelet analysis. First, it proposes a brain age estimation model construction method in MR images. Next, it shows a method of constructing spatiotemporal statistical shape model (stSSM) for the sake of statistically modelling individual variety of organ shape and it's temporal change due to growing or disorder development. And, it introduces Alzheimer's disease identification method using machine learning and stSSM-based feature extraction. Finally, to automatically recognize anatomical structure in ultrasound images, it describes an automated method of recognizing layered muscle and fat tissue in-vivo using wavelet analysis.

The first chapter consists of introduction and summary of this research, and describes research background and motivation.

The second chapter describes an age estimation method based on brain shape in MR images. The cerebrum deforms not only with growing or aging but also brain disorders. Thus, the difference between the physiological age estimated from brain MR images and real age can be an index of brain disorder diagnosis. This chapter extracts the anatomical landmarks from brain MR images, and estimates the physiological age using relative position vector of the landmarks and machine learning methods.

The third chapter proposes a construction method of stSSM to statistically characterize the temporal change of individual variety of organ shapes. stSSM is an extension of statistical shape model (SSM) in the temporal domain. The method creates stSSM using an expectation-maximization (EM) based weighted PCA (wPCA) learning framework. The weight function is defined as a Gaussian function, and by shifting the weight function with the analyzing time point, it is able to create continuous deforming model. An application of this model is also introduced which involves Alzheimer's disease identification by utilizing support vector machine.

The fourth chapter describes an automated method of recognizing layered structure of muscle and fat tissues in-vivo using wavelet analysis, in order to automatically recognize anatomical structure in ultrasound images. Non-invasive measurement of muscle thickness is effective for rehabilitation assessment, health management for elderly person, etc. The proposed method utilizes continuous wavelet transformation (CWT) employing the complex Gaussian wavelet to determine the interface between the muscle and fat from ultrasonic waves.

Finally, the fifth chapter summarizes the achievements of this study, and describes future works.